

SECTION 102

NOISE AND VIBRATION

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11 102.1 REFERENCES

- 12 (102A) ISO 6954
- 13 (102B) SNAME - Technical and Research Bulletin No. 2-29
- 14 (102C) SNAME - Technical and Research Bulletin No. 3-37, *Design Guide for*
15 *Shipboard Airborne Noise Control*
- 16 (102D) ASHRAE - *Applications Handbook*, 2003 Edition, Chapter 47, *Sound and*
17 *Vibration Control*

18 102.2 INTRODUCTION

19 This Section contains the Contractor Design and Provide general requirements to address
20 noise and vibration criteria, analyses required to predict noise and vibration levels in order to
21 determine appropriate treatments, measurement techniques to be employed in assessing
22 compliance with the criteria, and corrective actions required wherever compliance with the
23 criteria is not demonstrated.

24 *For WSF Fleet-wide Standardization purposes, End No. 1 of the Vessel shall always be*
25 *considered the bow, and this designation shall delineate port and starboard, fore and aft*
26 *wherever they are addressed in the Technical Specification.*

102.3 GENERAL

Throughout other Sections of the Technical Specification, specific design measures and treatments are called for to assist in noise and vibration mitigation. Examples include the requirements for an acoustically treated Engineer Operating Station (EOS) with “floating floor” deck, bulkhead, and ceiling treatments; resilient mounts for the Main Engines, diesel generators, compressors, fans and blowers; acoustically treated ventilation ductwork, bulkheads and decks; noise attenuation silencers and louvers for ventilation supply/exhaust systems; and Main Engine combustion intake air filters. Such required treatments shall supplement and be coordinated with other treatments selected by the Contractor in order to satisfy the noise and vibration criteria.

Noise and vibration criteria apply to calm water operation of the Vessel in conditions from light load waterline through full load, with the Main Engines operating at all power levels through maximum rated power, and with concurrent operation of generators and normally operating auxiliaries such as air compressors, circulating pumps, air conditioning, and ventilation.

The Vessel design and construction shall incorporate the provisions of the Contractor’s Noise Control Plan and Vibration Control Plan as set forth in Section 100 of the Technical Specification.

102.4 NOISE CRITERIA

Airborne noise levels in interior spaces and topside weather deck locations shall not exceed the limits of **TABLE 102-1**. Spaces not listed in **TABLE 102-1** shall have the same airborne noise criteria as listed spaces that support similar functions.

Each Officer and Crew Stateroom shall be sound insulated for privacy along **all** boundary bulkheads. An acceptable design standard for privacy is an airborne sound insulation index (Ia) of 20 dB. Insulation shall be upgraded as necessary to meet the noise limitations of **TABLE 102-1**.

Airborne noise levels shall be measured throughout the Vessel during Tests and Trials as described in this Section, and Section 101 of the Technical Specification, to demonstrate compliance with the noise limits listed in **TABLE 102-1**.

102.5 VIBRATION CRITERIA

Vibration in normally occupied spaces shall be limited to a maximum allowable velocity of 160 mils/sec (4 mm/sec) in maximum repetitive amplitude terms for a frequency range of 1 to 100 Hz in accordance with revisions to References (102A) and (102B).

The vibration of the main masts and other structures supporting vibration-sensitive equipment shall be limited to that level acceptable to the equipment manufacturers, or $\pm 0.1g$ over the frequency range of 1 to 100 Hz, whichever is less.

TABLE 102-1 Compartment and Topside Station Airborne Noise Limits		
Compartment Type	Total Noise not to Exceed (dB(A)) see Notes: 1 & 2	<u>HVAC only</u> Noise Level not to exceed (dB(A)) See Notes: 1 & 9
Auxiliary Machinery Rooms (Lower Vehicle Deck and below, except as noted)	100 (see Note 7)	80
Engine Rooms	110 (see Note 7)	80
Reduction Gear Rooms	95 (see Note 8)	80
Auxiliary Machinery Rooms (above Lower Vehicle Deck, except as noted)	90	80
Storage Rooms and Lockers	84	75
Engineer's Operating Station, Day Room & Chief Engineer's Office	70 (see Note 7)	60
Engineer's Workshop	75 (see Note 7)	70

TABLE 102-1, cont'd**Compartment and Topside Station
Airborne Noise Limits**

Compartment Type	Total Noise not to Exceed (dB(A)) see Notes: 1 & 2	<u>HVAC only</u> Noise Level not to exceed (dB(A)) See Notes: 1 & 9
Emergency Generator Room	110	80
Miscellaneous Lockers	84	75
Passenger Deck Lounges	65	60
Cafeteria	65 (see Note 4)	60
Small Galley	65 (see Note 4)	65
Passageway / Stairwell	65 (see Note 5)	60
Passageway / Stairwell	75 (see Note 6)	60
Deck Crew Shelter, Crews Day Room, and Sun Deck Day Room	65 (see Note 7)	60
Officer and Crew Staterooms	60 (see Note 3)	55
Pilothouses	60	55
Toilet & Shower Spaces (Ventilated Areas)	70	60
Exterior Passenger Deck Areas	75	65

TABLE 102-1, cont'd Compartment and Topside Station Airborne Noise Limits		
Compartment Type	Total Noise not to Exceed (dB(A)) see Notes: 1 & 2	<u>HVAC only</u> Noise Level not to exceed (dB(A)) See Notes: 1 & 9
Vehicle Decks – Underway	84 (see Note 7)	70
Vehicle Decks – Dockside/Loading	75	70

NOTES:

- 1) dB(A) ref: 20 MicroPa.
- 2) Criteria do not apply to operation of portable appliances, but do apply to operation of machinery which are intermittently operated or automatically cycle “on-off” such as Elevators and compressors. The criteria apply with the Emergency Diesel Generator (see **Note 3**), Anchor Winch, and Rescue Boat davits secured.
- 3) The airborne noise limits with the Emergency Diesel Generator in operation, shall be equal to or less than seventy-two (≤ 72) dB(A).
- 4) Applies to storerooms such as boatswain locker; food vending areas ready storage lockers; and similar spaces.
- 5) Applies to passageways/stairwells serving Passenger spaces and Officer and Crew Staterooms and work areas throughout the Vessel, except casing stairwells leading from Vehicle Deck Spaces to these areas.
- 6) Applies to all passageways/stairwells not covered by **Note 5**, including casing stairwells leading from Vehicle Deck Spaces and passageways/stairwells serving infrequently used storage areas and miscellaneous machinery spaces.
- 7) Applies with Main Propulsion Machinery (Engines, Reduction Gears and Shafting) operating at maximum continuous rating.
- 8) Noise levels shall be measured and recorded in each Reduction Gear Room while underway at design full power, with the noise microphone located (location negotiable). A spectrum analysis of the recorded noise shall contain no filtered peak exceeding 95 dB(A), whose frequency coincides within 5-percent (5%) of any Reduction Gear element rotational frequency, or multiple orders thereof, including tooth orders.
- 9) HVAC only noise levels shall be with all heating, ventilation, and air conditioning equipment operating at maximum capacity. Main Engines, generator sets, and all other machinery shall be shutdown.

The foundations of the Main Engine/Reduction Gear sets shall be such that the global foundation natural frequencies are at least 1.4 times the fundamental rotational frequency of the Main Engine. Global foundation natural frequencies are those for which the ship structure participates significantly.

102.6 SPARE PARTS AND INSTRUCTION MANUALS

Provide a list of recommended spare parts and special tools for those items which are Contractor furnished, together with parts lists and instruction manuals necessary to maintain and service provided equipment and accessories in accordance with the requirements of Sections 86 and 100 of the Technical Specification.

102.7 TESTS, TRIALS, AND INSPECTIONS

Tests and trials shall be provided in accordance with this Section and Section 101 of the Technical Specification.

Inspections shall be performed as defined in this Section and Section 1 of the Technical Specification.

102.8 PHASE II TECHNICAL PROPOSAL REQUIREMENTS

The following deliverables, in addition to others required by Section 100 of the Technical Specification and the Authoritative Agencies, shall be provided during the Phase II Technical Proposal stage of Work in accordance with the requirements of Section 100 of the Technical Specification:

- A. Noise Control Plan
- B. Vibration Control Plan
- C. Airborne Noise Analysis
- D. Vibration Analysis

The *Noise Control Plan* shall address plans for integrating engineering, administrative, management, and construction functions to ensure that airborne noise will not exceed the limits established in the Technical Specification. The engineering design and analysis steps to be applied to develop Contract and detail designs meeting the requirements shall be discussed. The Plan shall also identify countermeasures (insulation, “floating floor” treatments, etc.) that will definitely be used, as well as countermeasures that may be used pending design development, to limit the technical risk that noise will exceed the established limits.

The *Vibration Control Plan* shall address plans for integrating engineering, administrative, management, and construction functions to ensure that vibration will not exceed the limits set forth in this Section and other Sections of the Technical Specification. The engineering

1 design and analysis steps to be applied to develop Contract and detail designs meeting the
2 requirements shall be discussed. The plan shall also identify countermeasures (resilient
3 mounting systems, structural design features, etc.) that will definitely be used, as well as
4 countermeasures that may be used pending design development, to limit the risk that
5 vibration will exceed the established limits.

6 The *Airborne Noise Analysis* shall provide calculations of predicted airborne noise levels in
7 all Vessel spaces and Weather Deck locations. It shall compare noise predictions with the
8 criteria, and fully describe acoustic treatments to be used to achieve necessary noise
9 reductions. Where it can be shown that calculations performed for a given space closely
10 approximate those required for similar spaces, separate calculations are not required for the
11 other spaces.

12 HVAC noise contributions shall include duct-radiated “breakout” noise as well as noise
13 emitted from duct openings and diffusers. Both fan and flow generated noise contributions
14 shall be included in the HVAC system portion of the Noise Analysis.

15 Reference (102C) shall be used as a guide in predicting machinery and ventilation duct noise.
16 For the HVAC portion of the Noise Analysis, information presented in Reference (102D)
17 shall be used. Other ASHRAE publications may also be utilized, provided the Contractor
18 fully documents publications from which data are extracted.

19 The *Vibration Analysis* shall be mathematical vibration Finite Element Analyses (FEA) of
20 the hull structure and Propulsion System. These analyses shall be used to affirm that the
21 vibration criteria will be satisfied. The analysis shall predict the low frequency response of
22 major substructures and local structural elements to hydrodynamic and mechanical driving
23 forces originating in the propulsion system and associated wake field. The analysis
24 frequency range shall encompass the primary excitation frequencies of these sources,
25 including dominant propeller blade rate frequencies and, where significant, machinery
26 forcing frequencies. Major substructure analyses shall include, as a minimum, global
27 superstructure response. Local structural element analyses shall include analyses of
28 repeating plate panels, stiffened plate panels between web frames, and transverse beams and
29 longitudinal girders.

30 Any design modifications necessary to meet the noise and vibration criteria shall be
31 identified in the analysis reports. The necessary corrections shall be made to the Vessel’s
32 design.

33 Where hydrodynamic and machinery generated forces and torques are required for a
34 particular analysis, it may be assumed that these forces and torques are developed with the
35 Vessel moving ahead, from either No. 1 or No. 2 End, at a constant speed in deep calm
36 seawater.

37 Analysis reports shall present analyses data, assumptions, indices and coefficients, and
38 calculations in sufficient detail to permit independent verification of the results. These

1 reports shall be organized, prepared and produced in accordance with Section 100 of the
2 Technical Specification.

3 **102.9 PHASE III DETAIL DESIGN AND CONSTRUCTION REQUIREMENTS**

4 Noise and Vibration Plans and Analyses, and other deliverables as required by Section 100
5 of the Technical Specification and the Authoritative Agencies, shall be provided during the
6 Phase III Detail Design and Construction stage of Work in accordance with the requirements
7 of Section 100 of the Technical Specification.

(END OF SECTION)